Binding energies of C^{5+} ion under Quantum and Maxwellian Dusty Plasma Environment

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Synopsis Potential felt by a moving test charge under both electron-hole droplet quantum plasma and classical dusty plasma environments are formulated. Binding energies of hydrogen-like carbon C^{5+} ion are estimated by variation technique.

Modification of the structural properties of foreign atoms or ions in external plasma environments is a subject of intense investigation for the last few decades due to its potential applications in different branches *e.g.* astrophysics, plasma physics, atomic physics etc. A bulk of studies on the behavioural changes of few-body systems in presence of plasma environment have been discussed by Dutta *et. al.* [1]. In this presentation, we will discuss the formulation of different time-independent effective potentials for two types of plasma environment-1.*electron-hole droplet quantum plasma* and 2.*classical dusty plasma*, followed by the effects of such potentials on the binding energies of hydrogen-like carbon C^{5+} ion, moving in those environments.
The effective potential felt by a test charge (q) under a plasma medium can be obtained by the following relation,

$$\varphi(\vec{r}) = \frac{q}{2\pi^2}\int \frac{e^{i\vec{k}.\vec{r}}}{k^2\varepsilon(\vec{k},\omega)} d^3\vec{k} \qquad (1)$$

where $\varepsilon(\vec{k},\omega)$ is the dielectric function of the medium. Using appropriate dielectric function for quantum plasma [2], we have shown that the effective potential $\varphi(\vec{r})$ is consisted of two parts : *Debye-Hückel potential* $\left[\frac{q}{r}e^{-\frac{r}{\lambda_q}}\right]$ and near-field wake potential $\left[\zeta r K_0\left(\frac{r}{\lambda_q}\right)\cos\theta\right]$, where λ_q and ζ being the effective screening length and wake coefficient respectively, are functions of plasma particle densities. $K_0(x)$ is the Macdonald function.
On using the dielectric function [3] for classical dusty plasma, one can get the effective potential $\varphi(\vec{r})$ [4] which is consisted of three parts, two of them are the same as in case of quantum plasma but with different coefficients and the third part $\left[De^{-\frac{r}{\lambda_t}}\cos\theta\right]$ comes from dust charge fluctuation effect [4].
Variation method is used to estimate non-relativistic energy eigenvalues of nl ($n = 1-4$ and $l = 0-3$) states of hydrogen-like carbon C^{5+} ion moving in quantum plasma environment [5]. Level crossing phenomenon and incidental degeneracy are observed in case of an ion moving in the quantum plasma environment.

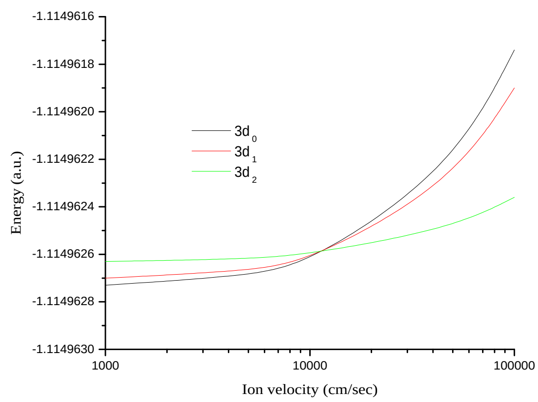

Figure 1. Plot of energy values (in a.u.) of $3d_0$, $3d_1$ and $3d_2$ states of C^{5+} against ion velocity (in cm/sec.) for plasma electron density $n_e = 10^{19}(/c.c)$. The subscripts denotes the absolute values of azimuthal quantum numbers of the states.

Similar features are also found in case of dusty plasma. The sole effect of dust charge fluctuation term in the potential is also studied [4]. It is shown that in the presence of dust potential part, the energy of $1s_0$ state becomes more positive by an amount of $26.8785 meV$.

References

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